TEST OF A DENSITY-DEPENDENT EFFECTIVE INTERACTION USING IN-PLANE ^{28}Si($\vec{p}$,$\vec{p}'$)^{28}Si POLARIZATION TRANSFER MEASUREMENTS

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Medium modifications of the effective NN interaction for isoscalar, natural-parity transitions have been studied by fitting the differential cross section and analyzing power data for ^{16}O($\vec{p}$,$\vec{p}'$)^{16}O at 135 MeV and 180 MeV, and ^{28}Si($\vec{p}$,$\vec{p}'$)^{28}Si at 180 MeV.[1,2] In this work, the transition densities were determined from electron scattering to minimize the uncertainties due to the nuclear structure, and the distorted waves were calculated using a self-consistent optical potential determined from the effective interaction. In order to parametrize the effective interaction inside the nucleus, a simple density-dependent form was chosen for the spin-independent isoscalar central and real spin-orbit components. The dependence of this form on momentum transfer was modelled to resemble Pauli-blocking corrections. The parameters were adjusted to produce the best possible agreement with the measured inelastic cross sections and analyzing powers. Even though it was not included in the data used for the fitting, the calculation of the elastic scattering cross section and analyzing power was consistent with the elastic scattering measurements as well. In addition, the effective interaction for ^{28}Si was shown to be consistent with the ^{16}O results.

The empirical effective interaction for the isoscalar natural-parity transition was studied without the benefit of any polarization transfer data. Thus, it is important to ask whether these results are sufficiently general that they may be used to predict other $(\vec{p}, \vec{p}')$ observables. For isoscalar, natural-parity transitions, DWBA calculations suggest that the polarization transfer coefficients follow a pattern similar to that for elastic scattering from a spin-0 target, namely that $P = A$, $D_{NN'} = 1$, $D_{LL'} = D_{SS'}$, $D_{SL'} = -D_{LS'}$, and $D^2_{LL'} + D^2_{SL'} + A^2 = 1$. For elastic scattering these relationships reduce the new information to one additional observable. While various authors often choose the spin rotation parameter Q, essentially any in-plane polarization transfer coefficient or combination of in-plane polarization transfer coefficients carries the same information.

The primary objective of Experiment E353 was the measurement of a complete set of polarization transfer observables for the two 6^- states in ^{28}Si at 11.58 MeV (T=0) and 14.36 MeV (T=1). As a part of that experiment, we chose to check the accuracy of the effective interaction for isoscalar, natural-parity transitions by measuring a combination (D_c) of the in-plane polarization transfer observables at low excitation energy for laboratory angles of 19° and 23°. This combination is defined by

$$D_c = D_\sigma \sin\theta + D_\lambda \cos\theta$$

$$= [p_S D_\sigma + p_L D_\lambda]/|p|$$

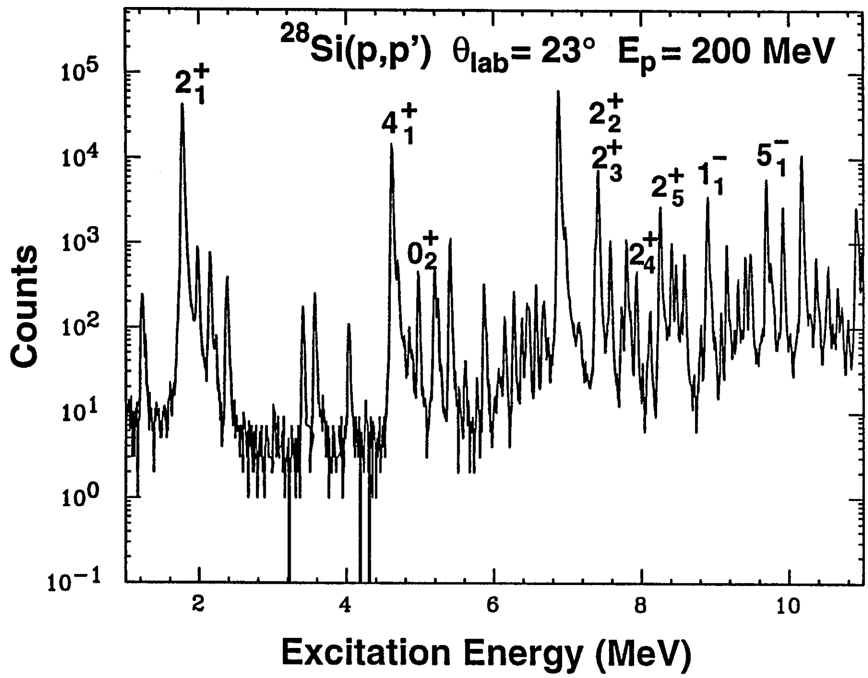

Figure 1. K600 focal plane spectrum for the low-excited states in ^{28}Si($\vec{p}$,$\vec{p}'$)^{28}Si. The states are labelled in a manner similar to that used in Ref. 2.

where

$$D_\sigma = D_{SS'}\cos\alpha + D_{SL'}\sin\alpha$$

$$D_\lambda = D_{LS'}\cos\alpha + D_{LL'}\sin\alpha$$

with θ defined to be the reaction plane angle between the spin direction and the longitudinal direction and α defined to be the spin precession angle through the K600 spectrometer relative to the proton momentum. The spin precession angle α depends on the proton energy and its path through the magnetic spectrometer. It is averaged over the paths allowed by the entrance collimator. For the states considered here, the θ and α values were about 115° and 242°.

The beam line polarization values were monitored continuously with the BL3 and BL5 p+d polarimeter. Particles were momentum analyzed by the K600 magnetic spectrometer with an energy resolution of about 50 keV for a 198.5 MeV proton beam. A spectrum for 23° scattering is shown in Fig. 1. The labels of these natural parity isoscalar states are the same as in Ref. 2. The 2_1^+, 4_1^+, 0_2^+, 2_3^+ and 5_1^- states were used in Kelly's determination of the interaction, while 2_2^+, 2_4^+, 2_5^+ and 1_1^- states were not chosen for the analysis of the effective interaction because of the lack of electron inelastic data to determine the transition density. The 2_2^+ and 1_1^- cross section data had large discrepancies with the calculated results from the fitted effective interaction, probably because of the uncertainties in the transition densities of these states.

Figure 2 shows the calculated D_c from Kelly's effective interaction for all of these transititions. The optical potential was calculated by folding the effective interaction with the three parameter Fermi density determined from elastic electron scattering. The

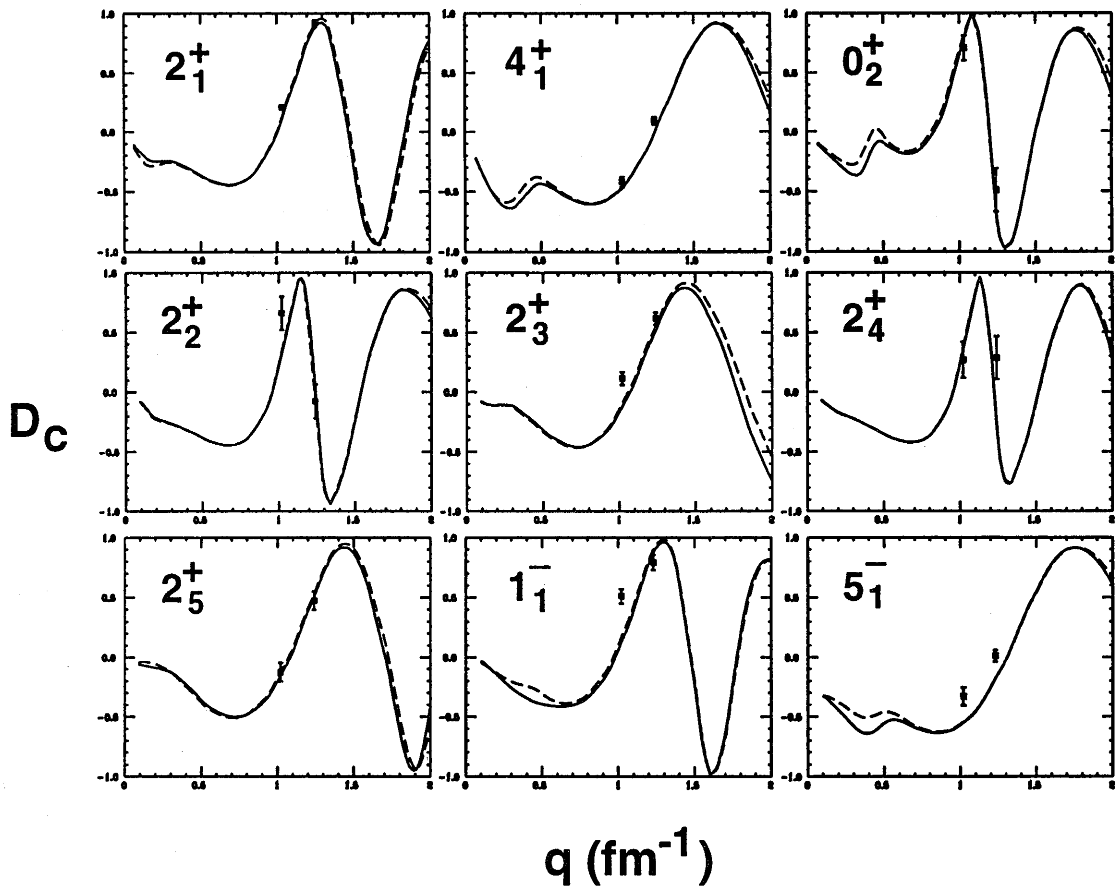

Figure 2. The calculated D_c value from Kelly's effective interaction, compared with data from E353. The experimental data are consistent with the empirical interaction calculations (solid) for all the natual-parity isoscalar transitions, but not with the von Geramb interaction (dashed).

transition densities were the same as calcluated in Ref. 2 and used the assumption that proton and neutron densities were the same. The match of the calculation with the data shows the medium modification of the effective interaction for spin-independent isoscalar transitions to be very successful. The accuracy of the calculations for the 2_2^+ and 1_1^- states does not reveal any serious problem with the spin-dependence of the transition densities used in the calculation. The dashed curves shown in Fig. 2 are the free (zero density) von Geramb interaction,[3] and the difference with the solid curves demonstrates the size of the effects due to the nuclear medium. From this result, it is clear that the empirically derived interaction is capable of accurately predicting other polarization observables in isoscalar (p,p$'$) reactions.

1. J.J. Kelly, *et al.*, Phys. Rev. C **41** (1990) 2504.
2. Q. Chen, *et al.*, Phys. Rev. C **41** (1990) 2514.
3. H.V. von Geramb, in *The Interaction between Medium Energy Nucleons in Nuclei – 1982,* ed. H.O. Meyer (AIP, New York, 1983), p. 44.